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ENVIRONMENTAL MANAGEMENT AT THE NEVADA TEST SITE YEAR 2001 CURRENT STATUS

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ABSTRACT

The performance objectives of the U. S. Department of Energy's National Nuclear Security Administration Nevada Operations Office Low-level Radioactive Waste (LLW) disposal facilities located at the Nevada Test Site transcend those of any other radioactive waste disposal site in the United States. Situated at the southern end of the Great Basin, 244 meters (800 feet) above the water table, the Area 5 Radioactive Waste Management Site (RWMS) has utilized a combination of engineered shallow land disposal cells and deep augured shafts to dispose a variety of waste streams. These include high volume low-activity waste, classified material, and high-specific-activity special case waste. Fifteen miles north of Area 5 is the Area 3 RWMS. Here bulk LLW disposal takes place in subsidence craters formed from underground testing of nuclear weapons. Earliest records indicate that documented LLW disposal activities have occurred at the Area 5 and Area 3 RWMSs since 1961 and 1968, respectively. However, these activities have only been managed under a formal program since 1978. This paper describes the technical attributes of the facilities, present and future capacities and capabilities, and provides a description of the process from waste approval to final disposition. The paper also summarizes the current status of the waste disposal operations.

Additionally, the Nevada Operations Office Environmental Restoration Division is responsible for identifying the nature and extent of contamination; determining its potential risk to the public and the environment; and performing the necessary corrective actions in compliance with guidelines and requirements. This paper summarizes just a few of the successes of the Nevada Operations Office projects.

WASTE MANAGEMENT

Introduction

In 1978, the Nevada Operations Office established a managed LLW disposal project at the Nevada Test Site (NTS). Two sites, that were already accepting limited amounts of on-site generated waste for disposal and off-site generated Transuranic Waste for interim storage, were selected to house the disposal facilities. In those early days, the sites, located about 24 kilometers (15 miles) apart, afforded the Nevada Operations Office the opportunity to use at least two alternative technologies to effectively manage its disposal cost. The Area 5 RWMS uses engineered shallow-land burial cells to dispose packaged waste while the Area 3 RWMS uses subsidence craters formed from underground testing of nuclear weapons for the disposal of packaged and unpackaged bulk waste.

Authorization Basis

The Areas 3 and 5 RWMSs are classified as radiological facilities. The authorization to operate the RWMSs is based on a variety of documents which may include but are not limited to Integrated Safety Management System Description, Activity Agreements, Real Estate and Operating Permit, appropriate Safety Analysis documentation, Execution Plans, Environmental Impact Statement, Health and Safety Plan, and procedures. A Disposal Authorization Statement (DAS) was received in October 1999 for Area 3. In October 2000, the Nevada Operations Office Manager approved the NTS Integrated Closure and Monitoring Plan as well as the Performance Assessment and Composite Analysis Maintenance Plan as required by the Area 3 DAS. A DAS for Area 5 was received in December 2000. The Area 3 and 5 RWMSs received initial determination of acceptability from U.S. Environmental Protection Agency (EPA) pursuant to the CERCLA Off-Site Rule, in July 1998. The determination of continued acceptability is evaluated annually.

Physical/Technical Attributes

The NTS is a federally owned facility located on the southern end of the Great Basin in south central Nevada. It consists of approximately 3,561 square kilometers (1,375 square miles) and is surrounded by the Nellis Air Force Range and areas controlled by the Bureau of Land Management. Manned guard gates control access to the NTS. The two disposal facilities are inside the boundaries of the NTS and are located 24 kilometers (15 miles) (Area 5) and 48 kilometers (30 miles) (Area 3) north of the main access gate. Remoteness to populated areas is a key feature that enhances the site characteristics. The closest populated area to either disposal facility is the small town of Indian Springs, NV located 55 kilometers (34 miles) to the southeast. Las Vegas, the closest major population, is approximately 105 kilometers (65 miles) southeast.

The Area 5 RWMS is located in the southeastern section of the NTS in Frenchman Flat, within a topographically closed basin where all surface water drains into a playa. The facility is sited on a coalesced alluvial fan, south of the Massachusetts Mountains. The water table is 244 meters (800 feet) beneath the facility. Site characterization studies show that there is no aerially distributed recharge to the aquifer in the vicinity of the RWMS. In fact, hydrogeologic testing in bore holes show that in approximately the upper 46 meters (150 feet) of the vadose zone, the movement of moisture is upward (negative water potentials).

The Area 3 RWMS is located approximately 24 kilometers (15 miles) north of the Area 5 RWMS in the Yucca Flat basin, another closed basin where all surface drainage terminates in a playa at the south end of the basin. The water table is 488 meters (1,600 feet) beneath this facility. Both facilities receive on average 10-15 centimeters (4-6 inches) of precipitation annually.

Measurements at meteorological stations show that annual potential evaporation exceeds precipitation by greater than a factor of 14, and a moisture deficient state is maintained in the surface soils. The Nevada Test Site Waste Acceptance Criteria (NTSWAC) limits the amount of free liquids the waste can contain to one percent of the volume of the waste in a container. This equates to approximately 2 liters (one-half gallon) in a 208 liters (55 gallon) drum or 32 liters (eight gallons) in a 1.2x1.2x2.1 meter (4'x4'x7') box. The adequacy of these limits was verified in the Area 5 RWMS Performance Assessment (PA). In the PA, no credit was given for the packaging of the waste. All waste and radionuclide inventories were assumed to be available to the transport process immediately upon final closure of each cell. A bounding scenario in the PA model assumed uniform closure cap subsidence to a depth of 1.8 meters (six feet) below grade, three successive 200 year flood events which filled the 1.8 meters (six foot) subsidence depression and then infiltrated the ponded water into the waste. Even under these extreme conditions, the disposal site did not exceed the regulated performance objectives.

Acceptance Process

The NTSWAC establishes the standard and requirements that generator sites must meet in order to receive approval to ship radioactive waste to the NTS. The NTSWAC covers the generator waste certification program, characterization of the waste, traceability, waste forms, and packaging and transfer of the material. The Radioactive Waste Acceptance Program (RWAP) personnel maintain the NTSWAC. The RWAP personnel review the generator's program and documentation to verify the generator sites capability to develop and maintain a NTSWAC compliant program. Waste profiles are reviewed, biennial program audits, annual assessments and periodic surveillances are conducted to verify and validate the Generators' Waste Management Programs. RWAP personnel can recommend the suspension of a generator program and/or waste stream that was found to be noncompliant or falls below standards described in the NTSWAC. In addition to the reviews by RWAP staff, the actual waste shipment and containers are inspected upon arrival at the RWMS facilities to verify items such as placards, manifests, marking and labeling, and container integrity.

Disposal Process

Both RWMSs are shallow-land disposal facilities, but there are differences between the sites. Area 5 has 296 hectares (732 acres) available for disposal of LLW. Current operations use 37 hectares (92 acres) of this total acreage, although expansion beyond this area is in process. Here, engineered disposal cells are used for disposition of waste. These cells are planned, designed and constructed to fit within the existing fenced area. At Area 5, LLW, Nevada Operations Office instate generated mixed low-level waste (MLLW), radioactively contaminated regulated asbestos, and classified LLW are disposed. High specific activity LLW was disposed in Greater Confinement Disposal (GCD) boreholes, however this disposal option is not currently being used. Additionally, there are facilities for the storage, characterization, and certification of Transuranic Waste.

The disposal cells at Area 5 are excavated, and consequently are more expensive to develop than the subsidence craters used at Area 3. The Area 5 disposal space has historically been reserved for conventionally packaged waste in containers such as steel drums and 1.2x1.2x2.1 meter (4'x4'x7') or 0.6x0.6x2.1 meter (2'x4'x7') wooden and steel boxes. On occasion, other container sizes are accepted on a case-by-case basis, such as the regulated asbestos cell that accepts 2.4x2.4x6.1 meter (8'x8'x20') cargo containers.

All packages accepted for disposal at Area 5 are required to meet the rigid U. S. Department of Transportation performance based packaging requirements. With the exception of cargo containers, the NTSWAC requires all boxes to meet a 16,113-kilograms/square meter (3,300-pound/square foot) compressive strength test. This provides a factor of safety for the workers. The waste packages are stacked one upon the other in a stair step configuration, until the stack is four feet below the top of the cell walls. Because these packages can weigh as much as 19,800 kilograms (9,000 pounds) each, there is the potential for the bottom box in the stack having to support in excess of 132,000 kilograms (60,000 pounds) of loading. Thus, strength criteria in conjunction with the stacking configuration ensure a secure work platform for the waste handling crew. Process safety is taken seriously, as the disposal operations have been accident free for more than six years.

The Area 3 RWMS covers 49 hectares (120 acres). Area 3 disposes waste in subsidence craters formed from underground testing of nuclear weapons instead of conventional engineered cells. The criterion used for choosing these craters was that the emplacement of the nuclear device had to have been above the water table. This criterion was chosen to ensure that no preferential pathway would be available to the underlying aquifers. These disposal cells are considerably less expensive to develop than the Area 5 cells because the waste is disposed in existing subsidence craters. The disposal process also differs significantly here. Small packages such as boxes and drums are replaced with larger bulk sized packages such as the previously mentioned cargo containers, large pieces of equipment, super sacks or soils in lined dump trailers, referred to as "burrito wraps." Instead of stacking the waste in a single monolith configuration, waste is disposed in a layer-cake geometry with each layer of waste covered by a layer of compacted soil ranging from 0.3-0.9 meters (1-3 feet) in depth.

Disposal Access

The NTS RWMS currently receives LLW from 21generators including: Aberdeen Proving Grounds; Allied Signal; Bechtel Jacobs, Oak Ridge National Laboratory; Bechtel Nevada; Boeing North American-Rocketdyne; British Nuclear Fuels Limited, Inc., Oak Ridge National Laboratory; Earthline Technologies; Fernald Environmental Management Project; General Atomics; International Technology Corporation, Las Vegas; Lovelace Respiratory Research Institute; Mound Plant; Paducah Gaseous Diffusion Plant; Pantex Plant; Princeton Plasma Physics Laboratory; Rocky Flats Plant; Sandia National Laboratories/California; and Sandia National Laboratories/New Mexico; Savannah River Site; and West Valley.

The Waste Management Programmatic Environmental Impact Statement Record of Decision for disposal of LLW and MLLW, issued on February 25, 2000, identified NTS as one of two regional disposal sites. It is anticipated during fiscal year 2002 that at least one new generator (Idaho National Engineering and Environmental Laboratory) will receive approval to ship LLW to NTS. Only Nevada Operations Office in state generated MLLW is currently accepted. However, Nevada Operations Office anticipates being operationally ready to accept MLLW from off-site generators in 2002.

Present And Future Capabilities For Waste Disposal

The current Area 5 RWMS inventory of disposal cells is 23; not including the GCD bore holes. These range in size from 25-345 meters (83 to 1,133 feet) long, 9-102 meters (30 to 336 feet) wide, and 4- 15 meters (12 to 48 feet) deep. The total disposed volume of waste in these cells is over 244,000 cubic meters (8.6 million cubic feet). Available open capacity in the fenced 37 hectares (92 acre) compound at Area 5, in existing cells, is approximately 137,657 cubic meters (5.9 million cubic feet). This includes the 20,000 cubic meters (706,000 cubic feet) being proposed for MLLW disposal. One new cell with a capacity of 28,317 cubic meters (1,000,000 cubic feet) has been constructed in the expansion area north of this fenced compound. No master plan currently exists for the layout of future cells across the total 296 hectares (732 acres). However simple calculations based upon existing inventory for the 37 hectares (92 acres) show that the current capacity averages 4,572 cubic meters per 0.4 hectares (161,000 cubic feet of waste per acre) of available ground. Extrapolation of this calculation for the total 296 hectares (732 acres), taking no credit for future technology such as deeper cells, shows the total capacity of Area 5 RWMS is about 3,337,194 cubic meters (118 million cubic feet).

The Area 3 RWMS includes a total of seven craters, representing five cells, designated for disposal operations. The current inventory of disposed waste at the Area 3 RWMS is approximately 379,478 cubic meters (13.4 million cubic feet). Open capacity available in the two developed cells is estimated to be approximately 189,662 cubic meters (6.7 million cubic feet). The two remaining craters, which at the present time are assumed to be individual cells, represent an estimated combined available future capacity of 203,000 cubic meters (7.2 million cubic feet).

In the five year period covering fiscal years 1997 through 2001, the NTS has received on average 643 shipments of LLW representing 21,096 cubic meters (745,000 cubic feet) of waste annually from as many as 21 waste generators. This volume of waste has been transported, received, and disposed safely with minimal risk to the general public, the workers at the disposal facility or the environment. A Conservative calculation of total remaining disposal capacity at the NTS is about 3,727,360 cubic meters (132 million cubic feet). This does not consider expansion into undesignated land surrounding the Area 5 RWMS or the inclusion of additional subsidence craters adjacent to the Area 3 RWMS.

The question of when NTS may reach its disposal capacity is dependent on the volume of waste received. Using 22,655 cubic meters (800,000 cubic feet) of waste received per year it will take approximately 156 years for the NTS RWMSs to reach capacity. Knowing that the waste volumes in the future will diminish as DOE completes the cleanup of the weapons complex and that the 156-year estimate does not include expanding into undesignated areas or future technology, NTS capacity is virtually unlimited.

Conclusion

The years of experience in waste management programmatic assessments and disposal operations, in conjunction with remoteness of the location, superior physical attributes (depth to groundwater, arid environment) establish NTS as one of the nations premier LLW disposal facilities. The issuance of the Waste Management Programmatic Environmental Impact Statement for LLW, and an available capacity of over 3.7 million cubic meters (130 million cubic feet), make the NTS LLW disposal facilities a keystone in the efforts to clean up and close the DOE sites across the complex, especially for those sites that are unable to dispose of LLW at onsite facilities or unable to access a commercial facility.

ENVIRONMENTAL RESTORATION

Introduction

Environmental Restoration activities in the state of Nevada are remediated under the Federal Facilities Agreement and Consent Order (FFACO). The FFACO is a 1996 agreement between the state of Nevada Division of Environmental Protection (NDEP), the DOE, and the U.S. Department of Defense (DoD) which outlines a schedule of clean up and monitoring commitments for sites contaminated at the NTS and TTR. Remedial action activities in other states are regulated by federal and state law.

Environmental restoration activities managed by the Nevada Operations Office are under the purview of two contractors. One contractor is responsible for site investigation; the other performs the actual remedial activities. This section of the paper highlights only a few of the major restoration project success

Offsite Projects (Amchitka Island and Central Nevada Test Area)

The Nevada Operations Office established the Offsite Project to address sites where nuclear weapons tests were conducted in the United States beyond the boundaries of the NTS. The Nevada Operations Office recently completed two of its remote remedial actions. The first was at Amchitka Island, Alaska, and the second was at the Central Nevada Test Area (CNTA), Nevada. These remedial actions consisted of mud pits that were contaminated with petroleum hydrocarbons and heavy metals. Contaminants were associated with the additives utilized during the drilling activities for the sites where tests were conducted. The mud pits had been approved for a closure in place with an engineered cap.

Amchitka Island was a sub-arctic environment with 12 mud pits identified for closure. Most of these mud pits contained standing water from rainstorms on top of drilling mud. Prior to capping activities, the standing water was removed, treated, and discharged. An engineered cover design included several cap layers, and a geomembrane, which provided the appropriate strength to support the cap itself.

At the CNTA, a multilayered cover with a geo-grid and geo-synthetic clay liner were designed to accommodate the high plains desert environment. In addition to this structurally adequate cover design, a monolayer vegetative cover utilizing native plant species was constructed to aid in controlling and reducing moisture. This vegetative cover reduced volume by 63% as compared to a multilayered conventional cover.

Even though the contaminated media (drilling mud) at each site were similar, the challenge facing the Nevada Operations Office Project Manager was not the construction design but the impacts created by the remoteness and extreme climatic conditions, requiring flexibility and adaptability of the strategies and designs to the environmental conditions.

The success of Amchitka in particular resulted in the ability to be flexible in the implementation of work scope and in having contingencies in place to deal with not only the technical challenges but also unfavorable weather conditions. Many valuable insights were gained in negotiation, partnering and cost sharing with other federal agencies. Having to barge in all necessary equipment and operate and maintain a base camp for a sustained period were all new experiences.

The success of the CNTA experience clearly resulted in a low maintenance vegetative cover in a remote location, which the regulator approved, in contrast to a standard RCRA cover, at a reduced overall cost.

Both projects were massive efforts; their successes can be directly attributed to the teamwork and collective contributions of the government agencies, contractors and regulators. Extensive pre-field planning and adaptable on-site management assured that the projects were completed within cost and schedule parameters, while guaranteeing the safety of all personnel.

Underground Test Area Project

The Underground Test Area Project (UGTA) was the new name given in 1992 to the Groundwater Characterization Project created in 1989. The UGTA project consists of fieldwork involving the drilling and testing of multiple boreholes, laboratory analysis of groundwater samples, and the development of hydrologic models and risk models in the NTS region.

The work is being conducted by multiple organizations familiar with the geology and hydrology of the NTS. The organizations involved are Bechtel Nevada (BN), International Technology Corporation (IT), Desert Research Institute (DRI), United States Geological Survey (USGS), Lawrence Livermore National Laboratory (LLNL), and Los Alamos National Laboratory (LANL). These organizations possess considerable knowledge of the NTS, obtained through involvement in the past underground-testing program.

An internal advisory group, the Technical Working Group (TWG), was also established to provide technical guidance and to assist the Nevada Operations Office in the management of the project. The TWG consists of experts in the fields of geology, hydrology, modeling, geochemistry, radiochemistry, engineering, and risk assessment. The members of this group contribute scientific and technical advice and recommendations to the UGTA Project Manager and provide internal peer review of the studies performed.

From 1957 to 1992, the DOE conducted 908 nuclear detonations in shafts and tunnels on the Nevada Test Site (NTS). These historical nuclear detonations are categorized into 878 Corrective Action Sites (CAS), which are further grouped into the following five geographically and hydrogeologically distinct Corrective Action Units (CAUs):

Frenchman Flat
Western Pahute Mesa
Central Pahute Mesa
Yucca Flat/Climax Mine
Ranier Mesa/Shoshone Mountain

Of the 908 underground detonations, approximately one-third of these detonations was conducted near or below the water table (600-2500 feet below surface) and has contaminated the groundwater. Monitoring of groundwater at private and public water supply wells and springs surrounding the NTS show no evidence of contamination resulting from underground nuclear testing.

The first step in the CAU evaluation process is to collect, assess, and evaluate the existing geologic, hydrologic, and radionuclide information available for each CAU. If sufficient data exist, then a groundwater flow and transport model will be developed utilizing these data. If sufficient data do not exist, additional data will be collected prior to developing the CAU model.

Modeling consists of developing a three-dimensional flow and transport model to define the maximum extent of contaminant transport for the CAU. Tritium and all other radionuclides with half-lives greater than tritium (12.32 years) will be evaluated to establish the contaminant boundary for each CAU. The boundary will define the maximum extent of contaminant transport in the horizontal direction as well as the lowest aquifer unit affected. After the contaminant boundary has been defined, various remedial alternatives will be evaluated and a corrective action proposed.

Currently, the UGTA project has completed a regional study that establishes the hydrologic setting for each of the CAUs under investigation. The characterization efforts are now focused on the smaller CAU scale investigations. Characterization data collection include activities such as drilling and completing new wells, re-completing existing wells, water sampling and analysis and performing surface geophysical studies such as gravity, magnetics and reflection seismic studies. The initial round of data collection, assessment, and evaluation of geologic, hydrologic, and radionuclide information has been completed for the Frenchman Flat, Western Pahute Mesa and Central Pahute Mesa CAUs. A second iteration of data collection is currently in progress for the Frenchman Flat CAU.

Industrial Sites Project

The Industrial Sites Project characterizes and remediates impacted sites that are the result or by-product of past testing and support activities at the NTS and the Tonopah Test Range (TTR).

Industrial sites listed in the FFACO first undergo an historical site investigation. Historical information is used to evaluate and prioritize Corrective Action Units so that corrective actions are optimized. In addition to investigating historical activity, current conditions and potential contaminants are also identified. Some industrial sites contain only discarded drums, batteries, and other debris. These sites are cleaned up as part of the "housekeeping" process and involve the simple removal of the debris.

Other industrial sites such as septic tanks, sewage lagoons, waste dumps, and facilities used in testing and support activities are more complex and are addressed by a lengthier process called "complex closure." As is the case with all Environmental Management sites, complex closure activities do not proceed until an approach coordinated with the state of Nevada. Complex closure begins with characterization of the site followed by recommendations for possible types of corrective actions. After a corrective action is chosen, a plan is devised to implement that action. When the plan has been implemented, a closure report for the site is prepared. If necessary, a closure report may include monitoring requirements. Once the Nevada Operations Office and NDEP are in agreement, NDEP will issue a notice of completion, marking the end of the complex closure process.

When enough information exists about the nature and extent of contamination, the investigation to determine a corrective action for site closure may be eliminated. This process, known as the Streamlined Approach for Environmental Restoration (SAFER), allows uncomplicated industrial sites, such as aboveground storage tanks and small spills, to be cleaned up in a timelier manner.

After an industrial site has been closed, the Industrial Sites Project conducts post-closure monitoring of the site as needed, which may include periodic collection of measurements and/or samples from monitoring wells. Monitoring activities are stipulated in the Post-Closure Monitoring Plan. Post-closure monitoring continues for a pre-determined period of time negotiated by the Nevada Operations Office and the state of Nevada. To date, the Industrial Sites Project has closed 619 (60 percent) of its 1044 EM corrective action sites. For FY 2002 and 2003, the project is planning to close an additional 49 sites.

To accomplish these closures, Industrial Sites staff constantly searches for new technologies that will help the closure mission. Two technologies were successfully deployed at the Nevada Test Site in FY 2001. The first involved the disassembly of a structure at the NTS. The baseline plan called for personnel to torch cut the facility, a process which would have taken two weeks. A search of technology led to the discovery of a crane, equipped with a hydrologic cutting bit, capable of cutting through I-beams. The result was the disassembly of the building in only three hours, without risk to the work force. The second technology, the Shot Blast System, is being used successfully at the large D&D facility (R-MAD) to remove radiologically impacted paint from the hot cell walls. The advantage is that the volume, and related disposal costs, of LLW is greatly reduced and the impacted paint is removed faster than the baseline technology of scabbling, also a cost and schedule savings.

Other activities that have led to the successful accomplishment of the Industrial Sites Project include successful negotiations with the state of Nevada. In FY 2000, NNSA/NV negotiated with the state of Nevada to allow the use of a non-RCRA cover (verses a traditional multi-layer cover) at a Part A permitted site, U3ax/bl, thus saving over $1.5 million in construction costs alone. Another success occurred in FY 2001 when NNSA/NV negotiated a strategy with the state of Nevada whereby only 257 of 3616 mud pits would be entered into the FFACO for characterization and potential remediation, thus saving approximately $294 millions.

Conclusion

The ultimate goal of Environmental Restoration is to complete corrective actions and ensure that the necessary long-term surveillance and maintenance programs are in place to protect the safety of the public and the environment. In all cases, the remedial strategy and design is tailored to the environmental conditions existing at the site being restored. Review of Lessons Learned and use of new technology serves to aid Environmental Restoration in accomplishing its mission. A positive working relationship with the state regulators aids also aids in accomplishing the mission at reduced cost and in shorter timeframes than originally anticipated.